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WORLDWIDE FREQUENCY of TEMPERATURES AT SELECTED ALTITUDES

by

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13. Abstract: This report provides maps that give frequency of occurrence of temperatures less than or equal to certain values at selected altitudes worldwide. Monthly data is plotted on world maps, with contours of probability. The analysis was performed using the Air Force Global Weather Central's HIRAS (High-Resolution Analysis) temperature and D-value data for 1985-1991. The analysis was accomplished for a 2.5 by 2.5 degree latitude/longitude global grid. The results of the analysis appear consistent with what meteorologists know about the atmosphere. The maps show USAFETAC's recently acquired data visualization capabilities.

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PREFACE

This report documents work done on USAFETAC Project 920720, "Worldwide Frequency of Temperatures at Selected Altitudes." The analyst was Lt James G. Saccomando, Jr., USAFETAC/DOS .

The study answered a request from the 645 WS/DOWA, Wright-Patterson AFB, OH, for the frequency of occurrence of temperatures less than or equal to a particular value at selected altitudes worldwide. They asked for the data by month plotted on world maps, with contours of probability.

The analysis was performed using HIRAS (High-Resolution Analysis) temperature and D-value data. A SAS program was used to acquire the required data from the 1985-1991 HIRAS tapes and calculate temperatures at the requested heights. Another SAS program computed percent occurrence frequencies. The analysis was accomplished for a 2.5 by 2.5 degree latitude/longitude global grid.

The results of the analysis appear consistent with what meteorologists know about the atmosphere. Land-sea temperature differences and the annual temperature cycle appear at lower altitudes (20,000 and 30,000 feet) and general circulation effects emerge near the equator at higher altitudes (40,000 and 50,000 feet). For example, what may be the results of monsoons over South Asia during the summer appear at 40,000 feet, and very cold air pools were found over Greenland and Antarctica at 20,000 feet.

INTRODUCTION

The 645 WS/DOWA tasked USAFETAC/DOS to determine percent occurrence frequencies of temperatures less than or equal to a particular value at selected altitudes worldwide and for each month of the year. The customer later asked for expansions of data for certain locations, such as Iraq, the former Soviet Union, and Panama.

Because of recently acquired data visualization color graphic capabilities made possible by its Macintosh computers, USAFETAC/DOS was able to prepare both color and black and white imagery that pinpoints percent occurrence frequency at specific locations.

Heights and temperature thresholds for this project follow:

20,000-ft (MSL) temperatures:
≤ -35°C ≤ -46°C
≤ -38°C ≤ -48°C

30,000-ft (MSL) temperatures:
≤ -37°C ≤ -51°C
≤ -43°C ≤ -53°C

40,000-ft (MSL) temperatures:
≤ -41°C ≤ -56°C
≤ -48°C ≤ -58°C

50,000-ft (MSL) temperatures:
≤ -45°C ≤ -61°C
≤ -52°C ≤ -63°C

METHODOLOGY

Input Data. To produce the imagery, it was first necessary to collect data. We used HIRAS data for several reasons. For one, HIRAS uses a variety of observations (e.g., surface, ship, buoy, aircraft, RAOB, PIBAL, rocketsonde, and satellite). HIRAS also produces data on a 2.5 by 2.5 degree latitude/longitude grid and includes data for all required pressure levels from the surface to 10 millibars.

Computing Percent Occurrence Frequency. Because the study required temperature percent occurrence frequencies at specified *heights* while HIRAS only reports at *pressure levels*, we had to create a height interpolator. The reported D-Value at a given pressure level provided the height of each pressure level. A log interpolation routine then determined temperatures at the required heights. The program calculated temperature at the required heights for every grid point in every available HIRAS report for the period 1985-1991 (about 800 reports per month per grid point). Finally, using a SAS frequency routine, the program produced the percent occurrence frequency data for each grid point for each month of the year.

Plotting Percent Occurrence Frequency Data. After collecting all the data, we created images on the Macintosh using *Atlas Mapmaker* and *Spyglass Transform*. A black and white contoured image of the percent occurrence frequency data was produced for each of the 192 month, height, and temperature range combinations (see Figures 1-5). We also produced color images of the same data. The color images (available on request from USAFETAC/DOS, 859 Buchanan St, Scott AFB IL 62225-5116) allow users to estimate temperature accurately at any point on the map. Each color represents a discrete percent occurrence frequency.

CONCLUSIONS

The analyses produced by HIRAS appear consistent with what meteorologists know about the atmosphere. The annual cycle appears at 20,000 and 30,000 feet in polar shifts of high and low percent occurrence frequencies to the north and south during the year (Figures 1 and 2). In June and July, higher temperatures are found in the north; in December and January, they are higher in the south. Also, land-sea surface temperature differences become visible at 20,000 feet, especially in Northern Canada, Greenland, Siberia, and Antarctica (Figures 3 and 4). At 40,000 and 50,000 feet, general circulation effects emerge near the equator. For example, what may be the results of the Monsoon Trough over the southern half of Asia during the northern hemisphere summer appears in the percent occurrence frequency map for temperature $\leq$ -48° C at 40,000 feet (Figure 5).

SUMMARY

The results of this project help showcase USAFETAC potential in the field of data visualization. Putting large quantities of data into visual form makes it possible for analysts to note *tendencies* immediately. Examples are the Monsoon Trough over India, a mesoscale sea breeze front over the coast of Florida, and microscale cloud motions at 20,000 feet. Recognizing these phenomena during analysis based on tabular data alone is not only difficult, but time-consuming. With visualization, inconsistencies in data almost leap out at the analyst. By observing the data relative to other nearby data, understanding the meteorology of a situation is faster and more accurate. Maps for the entire planet are now available for use with country data.

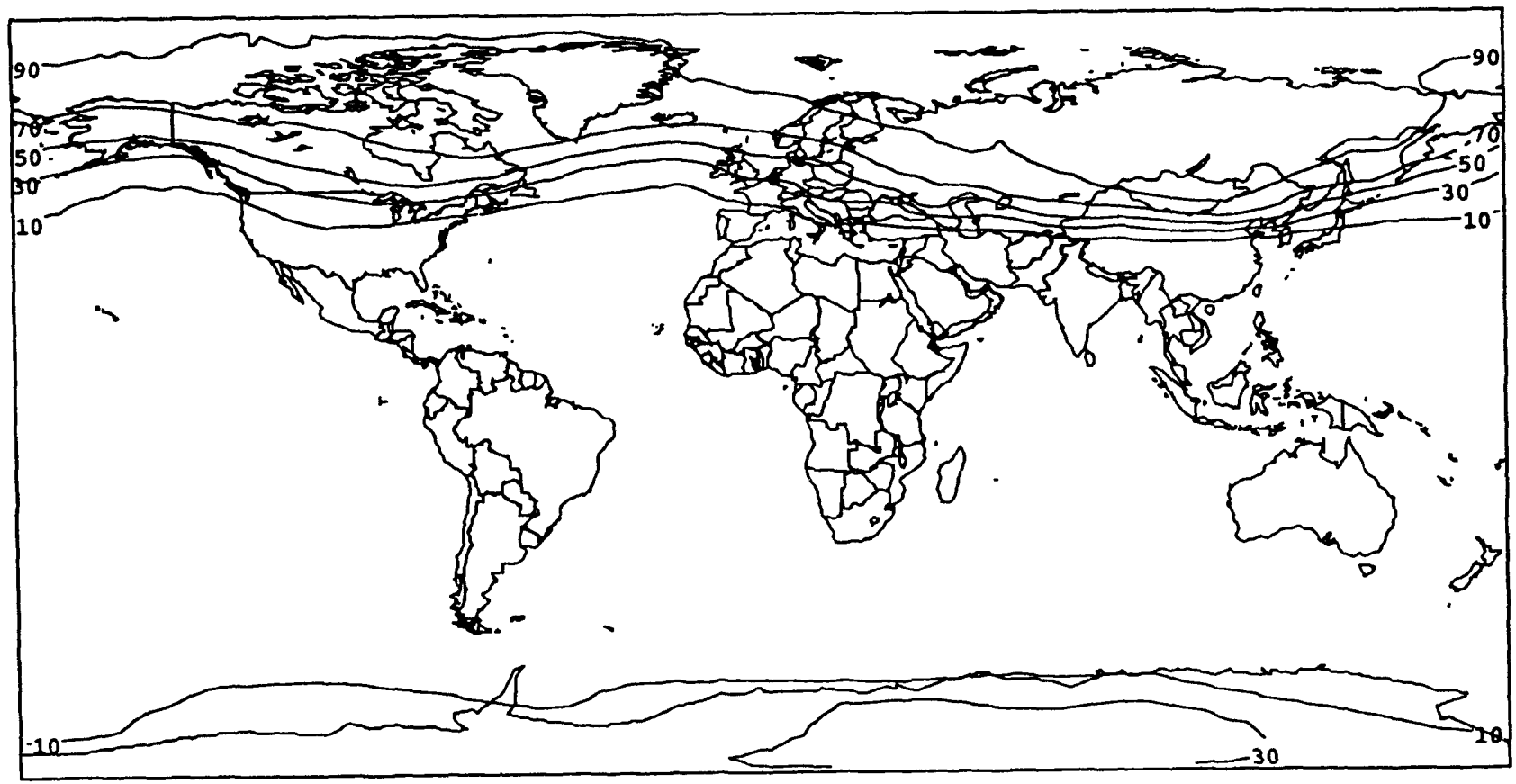

Figure 1. Percent Frequency of Occurrence of January Temperature ≤ -53° C at 30,000 Feet, 1985-1991.

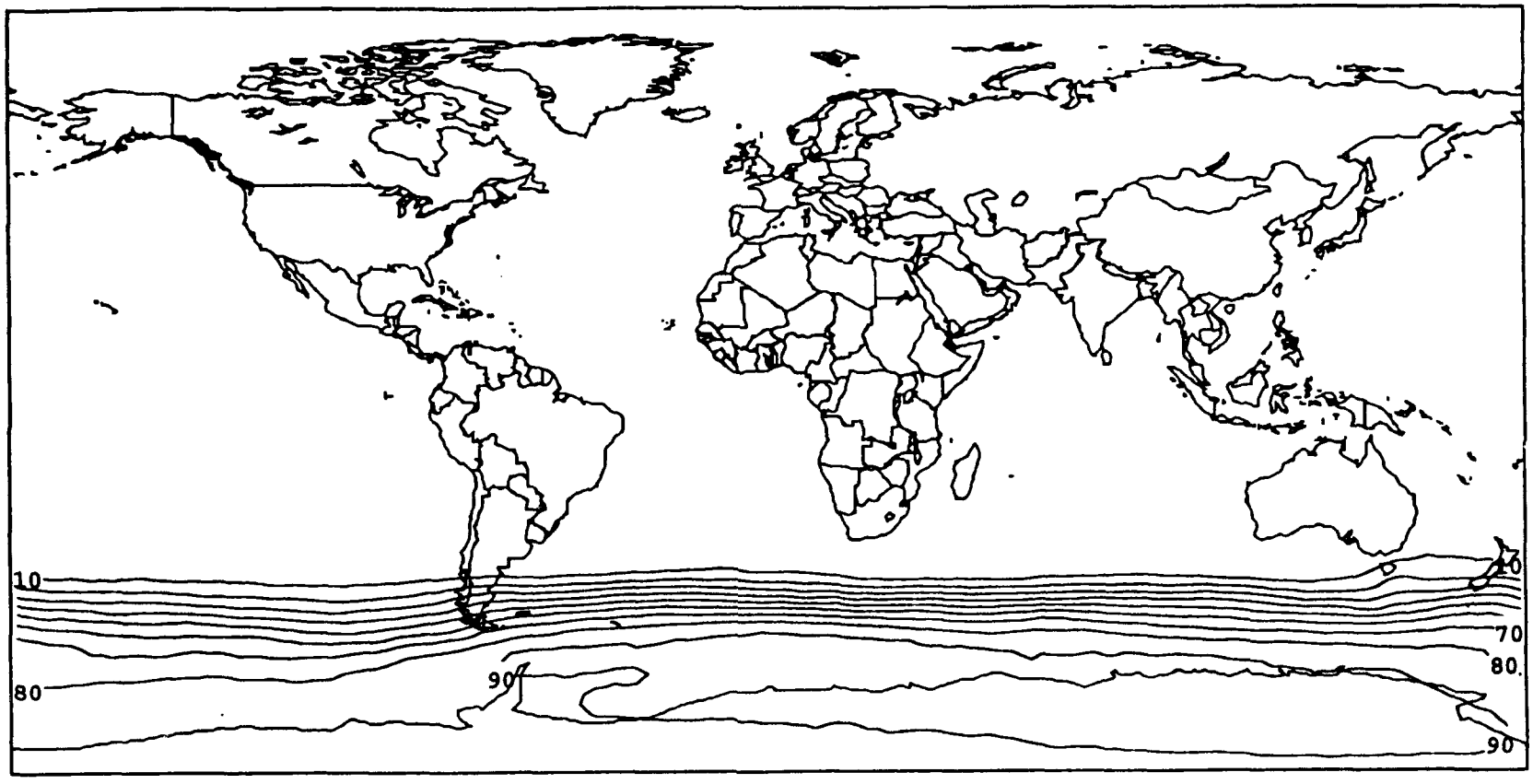

Figure 2. Percent Frequency of Occurrence of June Temperature ≤ -53° C at 30,000 Feet, 1985-1991.

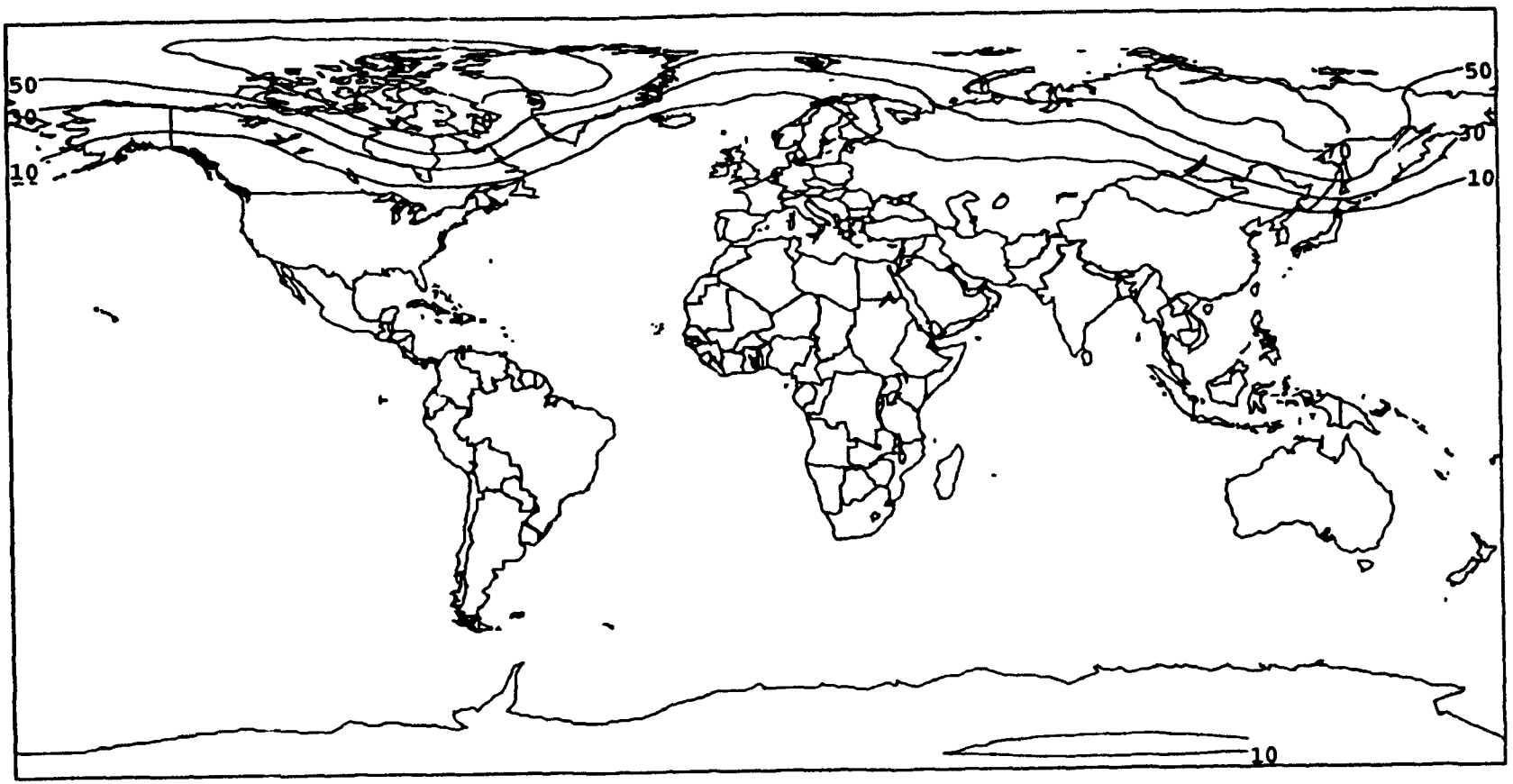

Figure 3. Percent Frequency of Occurrence of January Temperature ≤ -46° C at 20,000 Feet, 1985-1991.

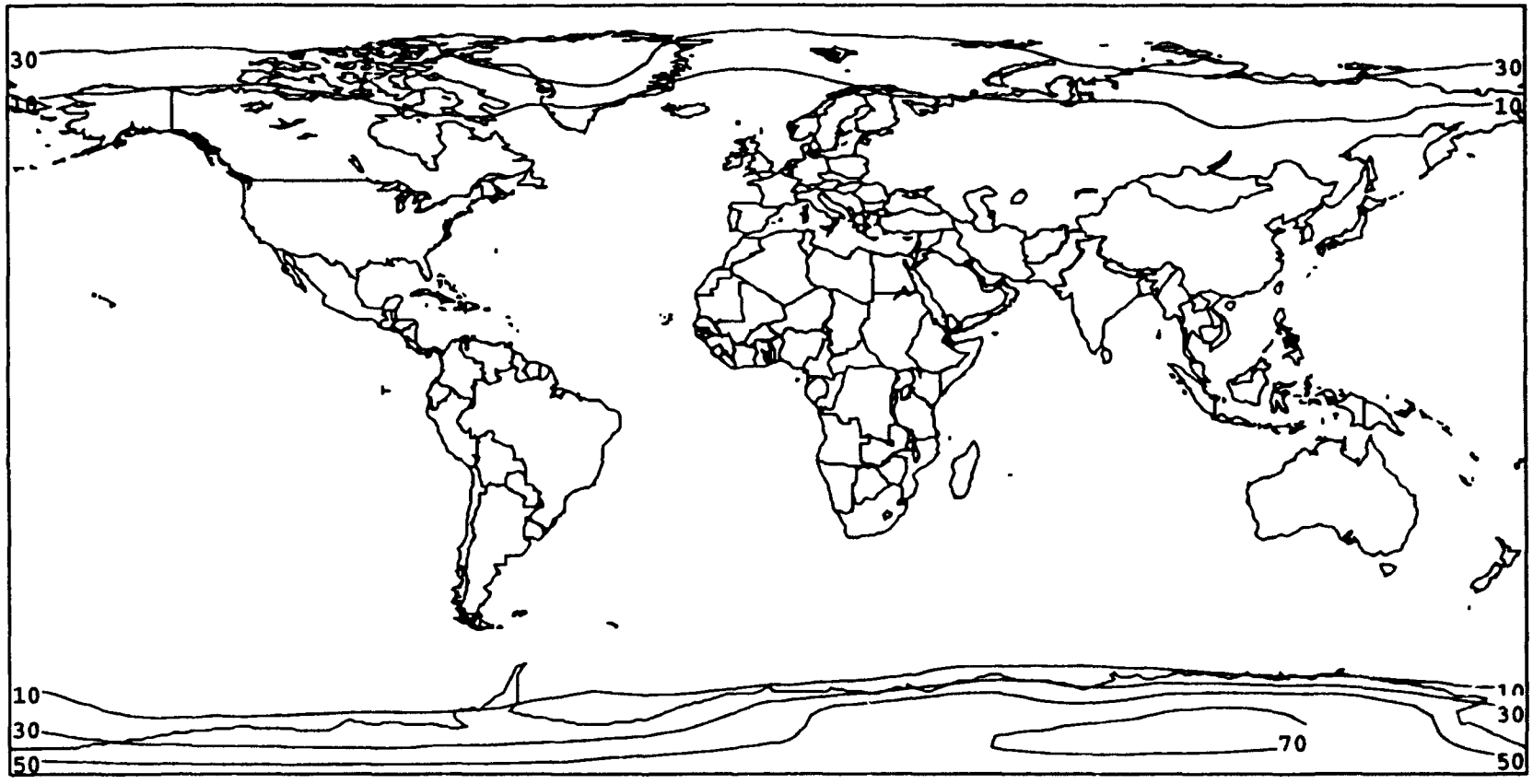

Figure 4. Percent Frequency of Occurrence of April Temperature ≤ -46° C at 20,000 Feet, 1985-1991.

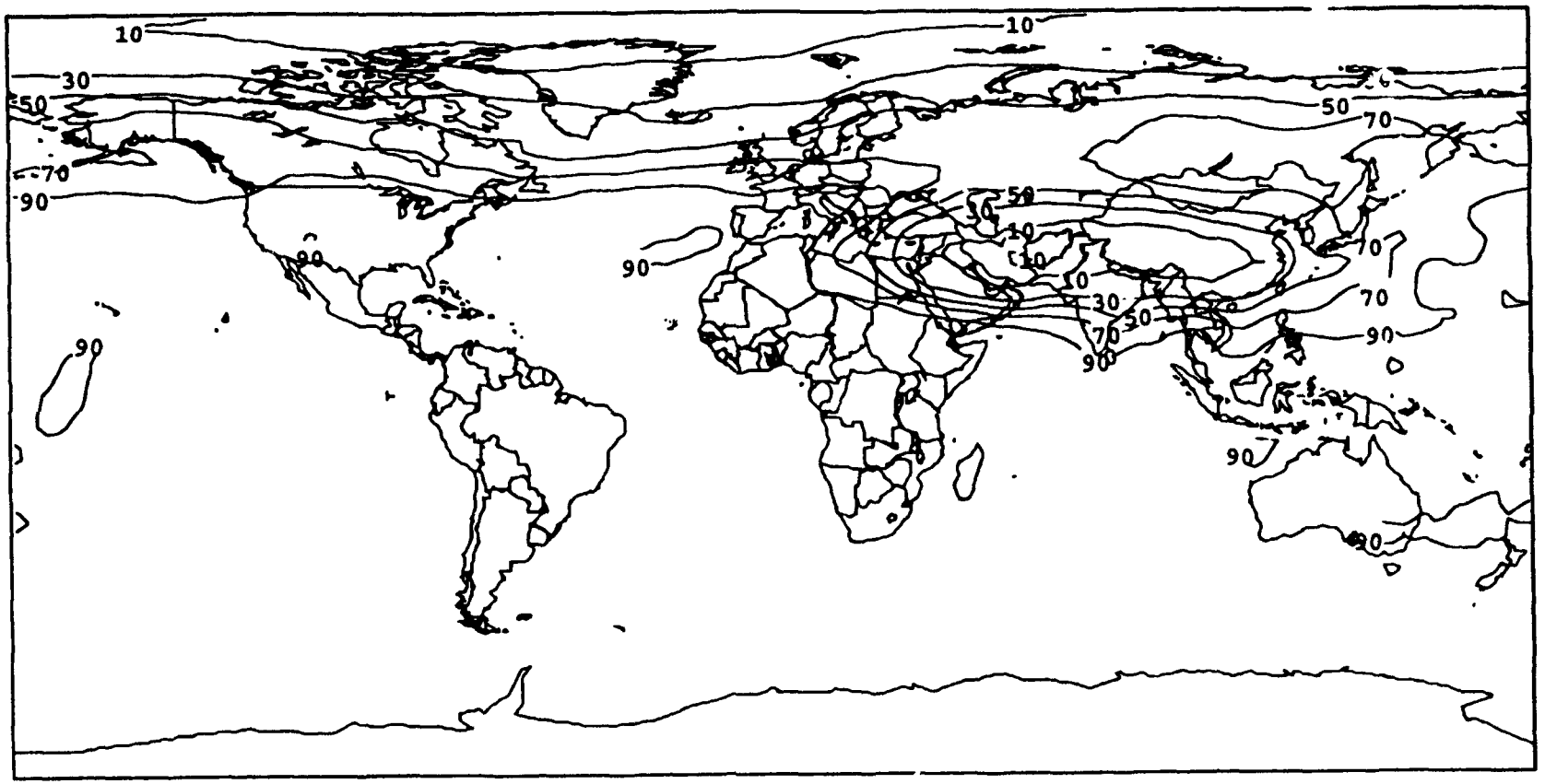

Figure 5. Percent Frequency of Occurrence of July Temperature ≤ -48° C at 40,000 Feet, 1985-1991.

GLOSSARY

645WS/DOWA	645th Air Base Wing Weather Squadron at Wright-Patterson AFB, Ohio.
AFGWC	Air Force Global Weather Central at Offutt AFB, Nebraska.
DOS	Special Projects branch of USAFETAC.
D-Value	Deviation of a pressure level's height from the standard height for that level.
HIRAS	High Resolution Analysis System. Upper-air analysis system produced by AFGWC.
SAS	Statistical Analysis System. Fourth generation computer language used at USAFETAC.
USAFETAC	United States Air Force Environmental Technical Applications Center at Scott AFB, Illinois

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